Acquisition Strategy
For
Electron Beam Ion Source Project
(EBIS)
at Brookhaven National Laboratory

Lead Program Office:

Office of Nuclear Physics
Office of Science
U.S. Department of Energy

Total Project Cost:

$ 14.8 million

July 2006

CONCURRENCES:

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ACQUISITION STRATEGY
for the
Electron Beam Ion Source (EBIS) Project

1. Desired Outcome and Requirements Definition

1.a. CD-0 Approval

At CD-0, the DOE total project cost (TPC) range was set at $16.0–$19.5 million but was reduced at CD-1 to $12.1 to $14.8 million. The scientific mission and technical scope have not changed since CD-0 approval. The original project schedule had been accelerated ~ 3 years to realize cost savings in Relativistic Heavy Ion Collider (RHIC) operations sooner, and use a $4.5 million contribution from the National Aeronautics and Space Administration (NASA) to reduce the total cost of the project to DOE. With the NASA contribution and refinements during the project engineering design phase, the DOE TPC at CD-2 is 14.8M$.

1.b. Summary Project Description and Scope

The mission of the Nuclear Physics (NP) program is to understand the evolution and structure of nuclear matter from the smallest building blocks, quarks and gluons, to the elements in the universe created by stars. A main objective of this nuclear science field is searching for the quark-gluon plasma and other new phenomena that might occur in extremely hot, dense plasma of quarks and gluons believed to have filled the universe about a millionth of a second after the "Big Bang." The EBIS is sited at the Brookhaven National Laboratory (BNL) RHIC, NP's flagship user facility for searching for new states of matter, such as the quark gluon plasma, created in hot, dense heavy ion collisions.

The Electron Beam Ion Source: The present pre-injector for heavy ions for RHIC uses the Tandem Van de Graaff accelerator, built around 1970, which if not replaced, will require substantial investments to maintain. BNL will construct a new heavy ion pre-injector for RHIC, the EBIS, which will lead to more reliable, cost-effective operations and new capabilities important for planned future upgrades of the facility. The EBIS will also provide for a major enhancement in capability for the NASA Space Radiation Laboratory (NSRL), which utilizes heavy-ion beams from the RHIC complex. EBIS will allow for the acceleration of all important ion species for the NASA radiobiology program, such as, helium, argon, and neon that are unavailable with the present Tandem injector. In addition, the new system will allow for very rapid switching of ion species for NSRL experiments, reducing delays due to the interference with RHIC injection operations.

The project scope, including DOE and NASA contributions, includes the fabrication of an Electron Beam Ion Source for the production of high charge state heavy ions, plus the procurement of a Radio Frequency Quadrupole (RFQ) and heavy ion Linac to accelerate ions from EBIS to its final energy. A transport line is to be fabricated to transport the beam from the output of the Linac to the existing Booster heavy ion injection point, as shown below in Figure 1-1. The project includes the fabrication or procurement of the dipole and quadrupole magnets,

power supplies, diagnostics, vacuum components, and controls to properly operate the EBIS source, accelerators, and beam lines. The project also includes the assembly of subsystems, and the installation and testing of these subsystems in their final location in the equipment bay at the high energy end of the existing Linac building.

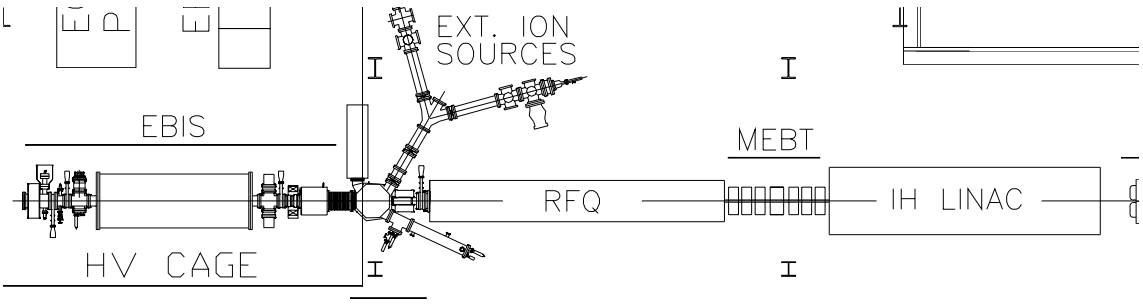

Figure 1-1 Layout of the pre-injector

The DOE scope is the following activities or procurements:

- All Project Engineering and Design (PED), installation, and commissioning for the entire project
- All EBIS chambers, internal structures, and warm magnets
- The Low Energy Beam Transport (LEBT) and external ion injection lines
- All controls, diagnostics, cooling water systems, and vacuum components, except for some vacuum components related to the beam port
- All Medium Energy Beam Transport (MEBT) and High Energy Beam Transport (HEBT) beamline components, except for two HEBT dipoles
- All radio frequency (RF) systems for operation of the RFQ, Linac, and bunchers
- All power supplies for EBIS, LEBT, and external ion sources, except for the electron collector and fast pulsing EBIS platform supplies.
- Electrical services required for the operation of the pre-injector

The NASA scope is the procurement of the following items:

- The EBIS superconducting solenoid
- The Radio Frequency Quadrupole accelerator
- The Linac structure
- The buncher cavities
- The two HEBT dipole magnets and their power supplies
- The electron collector power supply
- All quadrupole magnet and steering magnet power supplies for the Linac,
- MEBT, and HEBT
- The fast pulsing power supplies for the EBIS drift tubes and platform bias.
- The beam port through the earth shielding between Linac and Booster, and some associated vacuum equipment

The DOE deliverables are complete when all the items listed as DOE scope, above, have been procured or fabricated; the EBIS, RFQ, Linac, and beam transport lines have been installed; and the CD-4 requirements from Table 1-1 in the next section have been verified.

1.c. Performance Parameters Required to Obtain Desired Outcome

The technical objectives of the new pre-injector need to meet requirements of both the RHIC and NSRL experimental programs. The corresponding performance specifications required at CD-4 are described in Table 1-1. CD-4 performance is to be demonstrated at the Booster input.

Table 1-1

	CD-4 Performance
Species	Fe, Au
Intensity	3×10^8 Au^{32+} / pulse 4×10^8 Fe^{20+} / pulse
Charge-to-mass ratio, Q/m	0.162 (Au) 0.357 (Fe)
Repetition rate	Demonstration of pulsing
Pulse width	10-40 μs
Switching time between species	Demonstration of switching
Output energy	2 MeV/amu

2. Cost and Schedule

2.a. Total Project Cost

The EBIS project is being funded by DOE-NP and NASA. With refinements during the project engineering design phase, the estimate for the DOE TPC at CD-2 is $14.8 million, including contingency of about $2.2 million. The cost estimate is based on current purchase orders, vendor quotes for equipment items and estimates for in-house labor supporting design, procurement and installation. Current departmental labor rates and all applicable overheads have been included. The overall project contingency is calculated by estimating the contingency contribution from each Work Breakdown Structure (WBS) element. Each contingency contribution is based on an assessment of the cost, schedule, technical and design risk and then summed to give the total project contingency. The project costs were reviewed and endorsed by a DOE independent review panel in May 2006.

Life-cycle cost: The elements of the EBIS Project could have a useful life of up to 25 years. Operational costs are expected to be more cost effective than present operations with the Tandems, translating to an estimated cost savings in RHIC operations of $1.46 million per year (’06 $), with approximately 100 k$ going to NASA, and the remainder going to DOE NP. Costs to operate EBIS are included in the RHIC Operations budget and are not considered incremental costs.

Table 2.1 Cost Baseline for EBIS project:

WBS	Title	M$
1.1	Structural components	1.5
1.2	Controls Systems	0.8
1.3	Diagnostics	0.7
1.4	Magnet Systems	0.3
1.5	Power Supply Systems	1.0
1.6	RF Systems	2.8
1.7	Vacuum systems	1.4
1.8	Cooling Systems	0.3
1.9	Facility Modifications	0.5
1.10	Installation	1.4
1.11	Project Services	1.0
1.12	Commissioning	0.2
1.13	R&D / CDR	0.7
subtotal		12.6
	Contingency	2.2
Total		14.8

2.b. Funding Profile

Table 2.2 shows the funding profile. Funds in Fiscal Year (FY) 2005 were for R&D and the development of a Conceptual Design Report (CDR); the Research & Development (R&D) efforts are completed in FY 2007. The design phases are funded from the PED funds. Construction activities are started in FY 2007. No construction funds will be used until Critical Decision 3 (CD-3), Approval to start construction, has been approved. Total funding requirements are consistent with the FY 2008 Project Data Sheet, but now reflect a shift of $100K from Preops to Construction in FY2008. The funding profile falls within the Program's outyear budget targets.

Table 2.2 Estimated Funding

$M

	FY 05	FY 06	FY 07	FY 08	Total
R&D	0.5	0.1			0.6
CDR	0.2				0.2
PED/EDIA		2.0	0.1		2.1
Cons			7.4	4.2	11.6
Pre-Ops				0.3	0.3
TEC		2.0	7.5	4.2	13.7
TPC	0.7	2.1	7.5	4.5	14.8

2.c. Key Milestones and Events

Milestones will be used as schedule events to mark the due date for accomplishment of a specified effort or objective. A milestone may mark the start, an interim step, or the end of one or more activities as needed to provide insight into the Project's progress. Table 2.3 shows the key performance milestones as presented in the PEP.

Table 2.3 Milestones

Project Milestones Level 0	
Critical Decision 0 (CD-0)	Q4, 04 (A)
Critical Decision 1 (CD-1)	Q4, 05 (A)
Critical Decision 2 (CD-2)	Q4, 06
Critical Decision 3 (CD-3)	Q1, 07
Critical Decision 4 (CD-4)	Q2, 10
Project Milestones Level 1	
RFQ Procurement Placed	Q4, 06 (A)
Linac Procurement Placed	Q2. 07
Beam Port Complete	Q4, 07
SC Solenoid Factory / Acceptance Test	Q1, 08
Building Addition Approved for Occupancy	Q3, 08
EBIS Safety Assessment Document Complete	Q4, 08
CASE for EBIS Approved by DOE	Q4, 08
BHSO Letter Approving Commissioning	Q3, 09
Beam Out of EBIS	Q3, 09
HEBT Dipole Installation Complete	Q4, 09
Beam Out of RFQ	Q4, 09
Beam Out of Linac	Q1, 10
Beam Through HEBT	Q2, 10
Project Milestones Level 2	
R&D EBIS Installed on HV Platform	Q1, 06 (A)
Electron Collector Procurement Placed	Q1, 06 (A)
Superconducting Solenoid Procurement Placed	Q2, 06 (A)
R&D High Voltage Beam Tests Begin	Q3, 07
Electron Collector Pressure / Vacuum Tested	Q1, 08
EBIS Drift Tube Structure Complete	Q3, 08
EBIS Preassembly Complete	Q4, 08
Electron Collector PS Acceptance Tested	Q2, 09
ARR Review Team for EBIS Appointed	Q2, 09
RF Amplifiers Acceptance Tested	Q2, 09
Accelerator Readiness Review	Q3, 09
EBIS Install Complete	Q3, 09
RFQ Tested to Full Power	Q3, 09
RFQ Installation Complete	Q4, 09
Linac Tested to Full Power	Q1, 10
Linac Installation Complete	Q1, 10
HEBT Beamline Installation Complete	Q1, 10
HEBT Dipole PS Acceptance Tested	Q1, 10

Critical Decision 2 approval, establishing the Performance Baseline, is planned for 4Q FY 2006. No construction funds will be used until CD-3 is approved.

3. Major Applicable Conditions

3.a. Environmental, Regulatory and Political Sensitivities

There are no environmental, regulatory or political sensitivities associated with the EBIS project; and there are no additional laws, agreements or other factors to significantly influence the project. BNL will provide staff with the required skills and experience to design and build the EBIS project onsite. In 2003, BNL received a NEPA categorical exclusion for "RHIC II", which included the EBIS project (Chicago office (CH) National Environmental Policy Act (NEPA) Tracking Number BNL-455). Due to scope changes, the DOE has reviewed the original NEPA determination and approval; once in October of 2003 and again in July 2006. These changes were determined to be within the scope of the original project NEPA categorical exclusion.

3.b. Others

There are no significant other sensitivities.

4. Risk and Alternatives (Technical, Location, and Acquisition Approach)

4.a. Alternatives:

A considered alternative is to not proceed with the construction of EBIS. If the new linac-based pre-injector is not built, significant upgrades to the Tandems will be required in order to ensure reliable long-term operation for RHIC. Construction began for the Tandem Van de Graaff facility in 1966, and it was commissioned in 1970. Many of the Tandem systems date back to 1960's technology, and need modernization. If one were not to proceed with the EBIS Project, an estimated $9M in Tandem reliability upgrades would be required in order to prevent unexpected failures of the Tandem from suspending RHIC operations for extended periods. In addition, upgrading the Tandems will not lead to new performance capabilities that are needed for the long-term plans of the RHIC facility or NSRL.

Before selecting the EBIS, alternative high charge state heavy ion sources were considered; in particular the Electron Cyclotron Resonance (ECR) source, and the Laser Ion Source (LIS). The EBIS was chosen as best meeting the requirements for a new RHIC preinjector, based on considerations such as intensity, reliability, flexibility in the choice of species, fast switching between species, etc.

The RFQ is the only technology choice for the first acceleration stage of the EBIS beam. The IH linac structure was chosen as the next acceleration stage in the baseline design. This is a low-risk choice, since there are many linacs of this type in operation, particularly the IH linac at CERN for acceleration of lead, which almost exactly meets the EBIS requirements. A superconducting heavy ion linac was considered, but suffers from higher cost and increased operational complexity. During the future detailed design phase, alternative room-temperature linac structures will be considered.

There is no location alternative for the EBIS other than BNL. The RHIC at BNL is presently the world's only heavy-ion collider and the construction of EBIS would not be pursued by the NP program if it were not to be located at BNL.

4b. Risk Analysis:

Cost and Schedule Risk: To the extent feasible, procurements will be accomplished by fixed-price contracts awarded on the basis of competitive bids. Incremental awards to multiple subcontractors to assure total quantity or delivery will be performed to reduce schedule risk. The cost estimates are based in part on existing contracts for the prototype, actual cost of production of similar items, in part on budgetary quotes, and in part on engineering experience.

The EBIS project includes foreign procurements. Due to the cost risk associated with an unfavorable dollar vs. Euro exchange rate change an average contingency rate of 35% has been applied to several key items. In addition, risk will be reduced by placing early procurements of some of these key items.

Uncertainties in the Booster operation schedule (for RHIC or NSRL) may impact the EBIS project schedule. This risk will be minimized by careful management of the project, since the majority of work can proceed in parallel with Booster operations. The HEBT dipoles, which can only be installed during a Booster shutdown, will be procured early to allow large schedule float. The beam port through the shielding wall between the Linac and Booster must also be done during a Booster shutdown period. This NASA-funded effort was planned for early installation during summer of 2006 in order to minimize schedule risk, and is complete.

Delays in project funding due to Congressional Continuing Resolution could delay the placement of several key long-lead procurements. This is perceived to be a high risk, so BNL will work closely with DOE and NASA to insure that adequate funds are available for key procurement, and there will be an attempt to avoid scheduling large procurements until late in the first quarter of a fiscal year. In addition, it is expected that some funds will be carried over from a previous fiscal year into the next to avoid impacts of potential Continuing Resolutions on efforts planned for the beginning of a given year.

Funding and Budget Management: Funding for the DOE project scope comes from the Department of Energy through the Nuclear Physics program. EBIS is listed in the FY 2007 President's budget request as a line item construction project. The TPC is $14.8 million and is included in the NP five year budget. NASA is contributing $4.5 million for tasks and hardware identified as part of the NASA scope. Reductions of funding in any given year could slow the implementation of the project.

Technical and Engineering: The technical risks of the EBIS design are low. The successful EBIS ion source pre-conceptual R&D program at BNL has greatly decreased any risk related to a source of this type reaching the planned performance requirements. A prototype EBIS has operated with the full required electron beam current of 10 A, which is a factor of 20 improvement over previous EBIS sources. Since EBIS scaling laws are very well understood,

the scaling of the source output by a factor of 2 from the prototype is achieved by a straightforward doubling of the EBIS trap length, that is, by doubling the length of the superconducting solenoid. The RFQ and the Linac accelerators are both mature technologies, with very similar devices operating successfully at BNL as well as at other accelerator laboratories. The plan is to procure these devices from laboratories where several similar units have been built previously. The RFQ order was placed in June 2006. (NASA funded construction)

Interfaces and Integration Requirements: The project receives program guidance and funding from the Office of Nuclear Physics (NP) and NASA. The Associate Director of NP serves as the EBIS Acquisition Executive (AE). Jehanne Simon-Gillo, Director for Facilities and Project Management Division, DOE-NP, is responsible for programmatic guidance and funding for the EBIS. The EBIS Federal Project Director at the DOE Brookhaven Site Office, Michael A. Butler, carries out implementation and project direction. Jim Alessi, BNL, is the Contractor Project Manager managing the project. The project has been integrated with site activities at BNL through the establishment of an Integrated Project Team that includes members from the scientific staff, project management, procurement and Environmental Safety & Health (ES&H) organizations, as well as DOE and NASA.

The technical components produced by the project will be installed according to a detailed integration plan. An objective of the project is to minimize the impact to the ongoing research program at RHIC.

Safeguards and Security: The project activities are completely unclassified, and no safeguards and security issues during design and fabrication are foreseen. No BNL safeguards and security requirements will be impacted during the course of fabricating EBIS and no issues are anticipated during the installation and operation at Brookhaven. Access to the BNL site is controlled to ensure worker and public safety and for property protection.

Location and Site Conditions: Components of EBIS will be fabricated by vendors, collaborating institutions and BNL at their respective sites. Final assembly of EBIS will take place in Building 930 of BNL with a matching beamline to the present RHIC accelerator chain.

Legal and Regulatory: The EBIS project will be in full compliance with all applicable Federal, state and local requirements. There are no known legal or regulatory issues that could impact this project.

Environmental, Safety and Health: This project must comply with all requirements of the NEPA and its implementing regulations, the Occupational Safety and Health Act, the BNL Integrated Safety Management (ISM) Program and applicable ES&H policies and regulations. A NEPA review has been completed and a determination made that EBIS is included under a Categorical Exclusion covering a range of research and related activities. No negative impacts to the environment have been identified or are anticipated as a result of this project. The principles of ISM will be incorporated into EBIS planning and execution. A primary objective of this project is to protect the environment and the safety of workers and the general public.

Stakeholder Issues: There are no significant stakeholder issues anticipated. The primary stakeholder in this project is the RHIC, Alternating Gradient Synchrotron (AGS), NSRL and NP scientific user community.

5. Business and Acquisition Approach

The DOE Office of Nuclear Physics has selected BNL as the prime contractor for EBIS. The main reasons for selecting BNL are:

- Much of the expertise required in designing and fabricating the EBIS source resides with the BNL staff.
- BNL staff has played the lead role in carrying out the R&D.
- BNL has a DOE-approved procurement system with established processes and acquisition expertise needed to obtain the necessary instrument components and build EBIS.
- BNL has experience at managing the design and construction of similar significant pieces of scientific equipment.
- RHIC, which would utilize EBIS, is at BNL.

5.1 Acquisition and Contract Types

BNL, as the prime contractor, is responsible for the design, procurement, fabrication, assembly and integration of the EBIS components.

It is anticipated that other BNL staff will carry out a significant portion of the work associated with the fabrication of the EBIS under standard BNL management practices. In many cases they will be best suited to specify, select and oversee procurement and installation. However, some activities related to this project will be most efficiently, and/or cost effectively, performed by members at universities or at other national laboratories. Such work will be carried out using subcontracts or other appropriate instruments and agreements. The subcontracts will specify deliverables and will include provisions for reports on progress and expenditures. They will be established in accordance with standard DOE and BNL procedures.

The EBIS procurement strategy is to use full and open competition to the maximum extent possible. The following methods of competition will be used where appropriate: Requests for Proposals (RFP), resulting in best value procurements, and Requests for Quotations (RFQ), resulting in procurements to the lowest responsive, responsible offeror. Equipment and material will be procured through fixed-price contracts. Sole-source procurements of one-of-a-kind equipment would be necessary in a case where only one qualified bidder exists.

Specifications will be developed for major procurements to define the performance and delivery requirements. Test and acceptance procedures for equipment and material will be defined in the individual procurement specifications for each item based on the needs of its specific function and manufacturer's recommendations.

5.2 Incentive Approach/Linkage to Performance Metrics

Contract incentives are not planned, but may be used if project management believes they are essential to keep the project on schedule. Incentives, if used, will include specific performance measures to assure that the desired outcome is achieved. BNL's contract with the DOE is a performance-based contract with fee-bearing measures related to project performance.

5.3 Competition

All actions will be competitive and fixed price procurements unless specifically authorized by the project manager(s) and will be in accordance with the DOE-approved BNL procurement policies and procedures.

6. Management Structure and Approach

6.1 Integrated Project Team (IPT), Organizational Structure, and Staffing Skills

The structure of the DOE EBIS Project organization is shown in Figure 6.1.

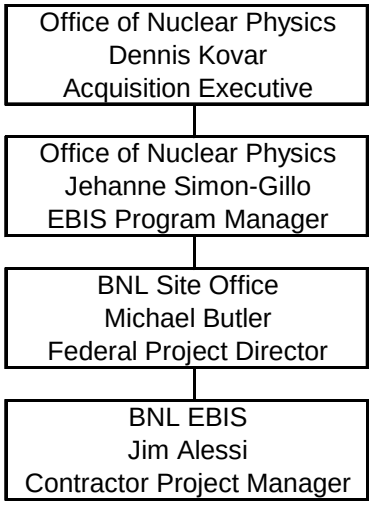

Figure 6.1. DOE EBIS Project Organization

Members of the EBIS IPT who participated in the writing of the Acquisition Strategy are shown with an * in Table 6.1. Consistent with DOE Order 413.3A and DOE Manual 413.3-1, there is an appropriate mix of skills among team members to successfully execute EBIS. Details regarding the IPT and BNL and DOE support functions for this project can be found in the preliminary Project Execution Plan. As the project progresses, membership of the IPT will change as needed.

Table 6.1 Integrated Project Team

DOE Federal Project Director (Chair)	Michael A. Butler*
DOE Site Contracting Officer	Michael D. Holland*
DOE Program Manager for EBIS	Jehanne Simon-Gillo*
DOE Science Program Manager	Gulshan Rai*
NASA Space Radiation Project Executive	Frank Sulzman
BNL Project Manager for EBIS	James Alessi*
BNL Procurement Operations Manager	David E. Dale*
BNL ESSH Lead	Ed Lessard*
C-AD Assistant Chair for Administration	Stephanie LaMontagne

6.2 Approach to Performance Evaluation and Validation

The Federal Project Director will monitor and evaluate EBIS performance against technical, cost, and schedule baselines through monthly reports, quarterly performance reviews, and day-to-day operational awareness. Variances to performance baselines will be reviewed and approved by a formal Baseline Change Control process as described in the preliminary Project Execution Plan. In-depth annual performance reviews with a panel of experts will be organized by the Office of Nuclear Physics, with participation from the Office of Science Office of Project Assessment.

The Change Control process is documented in the Project Execution Plan (PEP). The project control levels are defined in a hierarchical manner that provides change control authority at the appropriate level. The highest level of baseline change control authority is defined as level 0. Technical performance will be monitored throughout the project to assure conformance to approved project requirements. Design reviews, Title III inspections, and performance testing of the completed systems will be used to ensure that the facility meets all project requirements.

6.3 Interdependencies and Interfaces

EBIS is led by the host laboratory (BNL) with support from a number of collaborating institutions. The scope, organization, division of responsibilities, approvals, reporting, reviews, safety oversight and financial accounting for the design and/or fabrication of EBIS components has been established in a Memorandum of Understanding between DOE and NASA. A Statement of Work between BNL and NASA is also in place.

Activities that are related to the project include RHIC operations and NASA Radiobiology operations. Installation of the major technical components of the EBIS Project will need to occur such as to minimize impact to RHIC and NSRL operations.